Photography system that detects the position of a remote control and frames photographs accordingly

FIELD OF THE INVENTION

The present invention relates generally to photography.

BACKGROUND OF THE INVENTION

A common inconvenience in consumer photography is that the photographer cannot easily be included in the scene being photographed. Some cameras provide a "self-timer" that allows the photographer to compose a photograph, activate the timer, and place herself in the scene in time to be included in a photograph taken by the camera upon expiration of the timer. However, this solution requires considerable preparation and lacks spontaneity.

Other cameras include a remote control device that can activate the camera from a distance. The photographer can position the camera, place herself in the scene, and use the remote control to take photographs whenever she desires. However, this method generally gives the photographer little control over the composition of the photograph once the camera is positioned, and does not adapt well to changing scenes.

The inconvenience is particularly acute in video photography. The videographer must typically choose between letting the camera run unattended during an activity, resulting in an unartful recording, or removing himself from the activity for the duration of the recording to tend to the camera.

What is needed is a system and method for conveniently and artfully photographing or video recording a scene that includes the photographer.

SUMMARY OF THE INVENTION

A photography system includes a digital camera and a remote control whose location can be detected by the camera. The remote control includes a control for causing the camera to take a photograph. The camera selects a region to photograph from its field of view, based on the location of the remote control. The selected region may include the entire field of view of the camera or a portion thereof. The camera may optionally select a region that places the remote control in the center of the region. The photographer may optionally specify the size of the region to be selected. The camera may optionally adjust the size of the selected region to assist in photographic composition. The camera may optionally be capable of making video recordings.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 depicts a system in accordance with an example embodiment of the invention.

Figure 2 depicts a camera situated so that its field of view encompasses a relatively large area of interest.

Figure 3 shows a close up view of a remote control in accordance with an example embodiment of the invention.

Figure 4 represents an array of pixels.

Figure 5 depicts a particular region being selected from the camera's field of view.

Figure 6 illustrates how a selected photograph of the part of the scene encompassed by the selected region may compare with a reference photograph.

Figure 7 illustrates consecutive preliminary digital photographs and the detection of the position of an intermittent light in accordance with an example embodiment of the invention.

Figure 8 illustrates how a camera may select a selected photograph from a reference photograph.

Figure 9 shows a situation in which a selected photograph cannot be centered about the remote control location.

Figure 10 illustrates choosing the largest selected photograph that is centered on the location of the remote control light source.

Figure 11 illustrates an example technique for removing the light source from a video frame.

Figure 12 illustrates using optical zoom to improve the resolution of a selected photograph.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Figure 1 depicts a system in accordance with an example embodiment of the invention, and placed in an example photographic situation where the system can be used to good advantage.

Camera **100** may be placed on a tripod **101** or otherwise held substantially stationary. Camera **100** is directed at a scene to be photographed. Photographer **102** holds a remote control **103**, which can signal its location to camera **100**.

Camera **100** may have a zoom lens or a lens with a fixed focal length. If camera **100** has a zoom lens, it may be configured to a relatively short focal length so as to give the camera a relatively wide field of view. A relatively short focal length is one that is near the shortest focal length the camera is capable of. For example, in a

camera with a focal length range of 6 to 18 mm, a focal length near 6 mm would be relatively short. As shown in Figure 2, camera **100** is situated so that the field of view **201** of the lens encompasses a relatively large area of interest, from which regions may be selected to photograph.

Figure 3 shows a close up view of remote control **103**. In one preferred embodiment, remote control **103** comprises a light source **301**, to be used in signaling the location of the remote control **103**. Light source **301** may be a light emitting diode (LED), an incandescent lamp, or another kind of light source. It may emit light visible to the human eye, or light invisible to the human eye, for example infrared light, as long as the light can be sensed by the camera.

Remote control **103** also comprises various controls operated by the photographer **102**. For example, control **302** may cause the camera **100** to take a photograph. Controls **303** and **304** may cause the camera **100** start and stop the making of a video recording. Other controls may be present on remote control **103**.

A digital camera such as camera **100** typically uses a lens to project an image of a scene onto an electronic array light sensor. The electronic array light sensor typically comprises many light-sensitive elements sometimes called "pixels". Each pixel measures the brightness of light emanating from a corresponding location in the scene. The electronic array light sensor typically accumulates electrical charge in each pixel in proportion to the brightness of light falling on the pixel. This charge quantity is then measured to determine a numerical value. The numerical value is also often called a "pixel". The meaning of the term "pixel" is generally clear from the context of the reference. The set of numerical values resulting from the measurement of the charges from the pixels of the electronic array light sensor may be collected into a numerical array. The numerical array may be called a digital image, a

digital photograph, or sometimes simply an image or a photograph. When properly interpreted and displayed, the digital image reproduces the scene photographed by the camera.

In some cases, fewer than all of the pixels on the electronic array light sensor need be measured to determine numerical values. For example, if a photograph of lower resolution than the camera is capable of is desired, or if a photograph of only a portion of the camera's field of view is desired, some electrical charges may be discarded without being measured or saved.

Figure 4 represents an array of pixels **401**, and may be thought of as representing the light-sensitive pixels on an electronic array light sensor or as representing corresponding elements in a digital image array. Only a few pixels are shown in Figure 4 for simplicity of explanation. An actual camera may have many thousands or millions of pixels. Many digital cameras use selective wavelength filtering on some pixels to record color information about a scene, allowing such cameras to produce color photographs. One of skill in the art will recognize that the present invention may be embodied in a camera with color capability or one without.

In Figure 4, the entire array **401** corresponds to the entire camera field of view **201**, and in fact the size of the electronic array light sensor and the characteristics of the lens of camera **100** define the camera's field of view **201**. A subarray **402** of pixels may be selected from array **401** in order to select a particular region from the field of view **201** of camera **100**. In Figure 4, subarray **402** has its origin at row 3, column 5 of array **401**, and subarray **402** is four pixels wide and three pixels high.

Figure 5 depicts a particular region **501**, possibly corresponding to subarray **402**, being selected from the camera's field of view **201**. Figure 6 illustrates how a selected photograph **601** of the part of the scene encompassed by the selected region

501 may compare with a reference photograph **602** of the scene encompassed by the camera's entire field of view **201**.

In Figure 6, selected photograph **601** is framed such that light source **301** on remote control **103** is placed in the center of selected photograph **601**. If camera **100** can detect the location in its field of view **201** of remote control **103**, and if a region size has been specified or selected, camera **100** may accomplish such framing by selecting an appropriate subarray from reference photograph **602**. This subarray selection may be called "digital framing", as it simulates a photographer's framing of a photograph by selecting a scene region to photograph from a larger choice of possible regions. The digital framing may typically be done by a microprocessor, digital signal processor, or other logic that is part of the camera electronics.

In one example embodiment, the location of remote control **103** in camera field of view **201** may be accomplished as follows. Digital camera **100** may take a sequence of preliminary photographs. The sequence may be taken for the purpose of locating remote control **103**, for facilitating camera adjustments such as focusing or selecting a proper exposure, or for a combination of these. The preliminary photographs typically include the entire camera field of view **201**, but may be taken at a resolution lower than the camera's full resolution.

In this example embodiment, light source **301** on remote control **103** emits light only intermittently, blinking on and off repeatedly. This blinking or toggling of light source **301** provides a recognizable "beacon" that the camera can distinguish from features in the scene. When light source **301** is on and emitting light at a time when a preliminary photograph is taken, pixels on the camera's electronic array light sensor will receive light from light source **301**, and the digital values in the resulting preliminary digital photograph corresponding to the location of light source **301** will

indicate the presence of the light. Once light source **301** has switched off and a subsequent preliminary photograph is taken, the corresponding digital values will reflect only the scene illumination. The location of remote control **103** may be detected by comparing consecutive preliminary digital photographs and finding differences resulting from a change in state, the switching on or switching off, of light source **301**.

For example, Figure 7 illustrates consecutive preliminary digital photographs **701**, **702**, and **703**. For simplicity of illustration, the numeric arrays are reduced in size as compared with a typical digital photograph. Typically, brighter scene locations are indicated in a digital photograph with larger digital values, and darker scene locations are indicated with smaller digital values, although the opposite relationship is possible. Arrays **701** and **702** are substantially identical. Differences in the arrays, representing changes in the digital photographs, are revealed by subtracting, element-by-element, array **702** from array **701**. The resulting difference array is shown as array **704**. Only a few pixels have changed numeric value between preliminary photographs **701** and **702**, and only by small amounts. These changes may be attributable to random noise in the camera electronics, to subject motion, or other effects. In order to screen insignificant changes from consideration, difference array **704** may be subjected to a thresholding operation, wherein all values below a preselected value, for example 5 numeric counts in magnitude, are set to zero. Array **706** illustrates the result of such a thresholding operation. The fact that all elements of array **706** are zeros indicates that no significant changes occurred between preliminary photographs **701** and **702**.

A similar process reveals that between preliminary photographs **702** and **703**, significant changes did occur at two pixel locations. Two pixels in difference array

705 now have much higher numeric values, and those numeric values survive the thresholding operation as shown by array **707**. Because it is unlikely that there are other intermittent sources of light in the scene, remote control **103** can be confidently considered to be at the scene location corresponding to the significantly-changed pixels. The precise location in the camera's field of view may be determined by methods known in the art, such as by locating the largest change in pixel numeric value, or by finding the centroid of the pixels whose values changed significantly between consecutive photographs.

In one example embodiment, the size of selected photograph **601** may be specified in advance of taking any photographs. For example, reference photograph **602** capturing the entire field of view **201** of camera **100** and using all of the pixels on the camera's electronic array light sensor may comprise 2,592 pixels width in the horizontal direction and 1,944 pixels height in the vertical direction, but the camera operator may specify, using controls provided on the camera, that selected photographs such as selected photograph **601** are to be taken with a size of 1024 pixels width and 768 pixels height. These values are provided for illustration only; other sizes may be used within the scope of the appended claims.

Figure 8 illustrates how camera **100** may select selected photograph **601** from reference photograph **602**. In Figure 8, the camera **100** has located light source **301** of remote control **103** at pixel location (X_c, Y_c). The width and height of selected photograph **601** have been specified to be W and H pixels, respectively. Given these parameters, camera **100** has sufficient information to locate selected photograph **601** in reference photograph **602**. Designating the upper left corner of selected photograph **601** as pixel location (X_0, Y_0),

1) $X_0 = X_c - \frac{W}{2}$

and

2) $Y_0 = Y_c - \frac{H}{2}$.

If remote control **103** is located near any edge of reference photograph **602**, it may not be possible to position a selected photograph of a specified size in this way, as the boundaries of selected the photograph may extend outside the boundaries of reference photograph **602**. In this case, camera **100** may position a selected photograph so that light source **301** of remote control **103** is as nearly centered in the selected photograph as possible.

Figure 9 shows a situation in which a selected photograph of dimensions W by H pixels cannot be centered about the remote control location (X_c, Y_c). The dashed line shows the boundaries of selected photograph **901** as computed by formulas 1) and 2) above. In this case, the camera may choose selected photograph **901A** by adjusting the position of the selected photograph so that it retains its specified size, but is fully contained in reference photograph **602**.

As an alternative to adjusting the position of selected photograph **601** within reference photograph **602** when it is not possible to center a photograph of the specified size at the desired location, camera **100** may adjust the size of the photograph to be selected. For example, camera **100** may select the largest photograph that can be centered at the location of light source **301** on remote control **103** while maintaining the aspect ratio of the photograph constant.

Figure 10 illustrates choosing the largest selected photograph that is centered on the location of the light source **301** on remote control **103**. Light source **301** has

been located at pixel location (X_c, Y_c). Selected photograph boundary **1001** shows the location of the desired region.

Additionally, maximum and minimum sizes for the selected photograph may optionally be specified. A complete example set of rules for choosing the width W_1 and height H_1 of selected photograph are given in the algorithm listing below. The desired aspect ratio (the ratio of the photograph's width to its height, typically about 1.5) of the selected photograph is designated A, and the width and height of the reference photograph **602** are designated W_R and H_R respectively. The selected photograph may optionally have a minimum width W_{min} and a maximum width W_{max}.

Listing 1.

```
290     REM
300     REM   COMPUTE STARTING WIDTH AND HEIGHT, WITH OPTIONAL
310     REM      SETTING TO PRE-SELECTED MAXIMUM
320     REM
330     W1=MIN(Wmax,2*Xc)
340     REM
350     REM   COMPUTE CENTERING WIDTH AND HEIGHT WITH EDGE LIMITS
360     REM
370     H1=W1/A
380     IF Xc<W1/2 THEN
390        W1=2*Xc
400        H1=W1/A
410     END IF
420     IF Yc<H1/2 THEN
430        H1=2*Yc
440        W1=H1*A
450     END IF
460     IF (Xc+W1/2)>Wr-1 THEN
470        W1=2*(Wr-Xc-1)
480        H1=W1/A
490     END IF
500     IF (Yc+H1/2)>Hr-1 THEN
510        H1=2*(Hr-Yc-1)
520        W1=H1*A
530     END IF
540     X0=Xc-W1/2
550     Y0=Yc-H1/2
560     REM
570     REM   OPTIONAL SETTING OF SIZE TO PRE-SELECTED MINIMUM AND
580     REM      ADJUSTING POSITION
590     REM
600     IF W1<Wmin THEN
610        W1=Wmin
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620           H1=W1/A
630           X0=Xc-W1/2
640           Y0=Yc-H1/2
650           IF (Xc-W1/2)<0 THEN X0=0
660           IF (Xc+W1/2)>Wr-1 THEN X0=Wr-W1-1
670           IF (Yc-H1/2)<0 THEN Y0=0
680           IF (Yc+H1/2)>Hr-1 THEN Y0=Hr-H1-1
690        END IF
```

Once this example algorithm has completed, a selected photograph location and size are determined such that the selected photograph is no larger than the predetermined maximum size, is no smaller than the predetermined minimum size, is completely contained within the reference photograph, is as nearly centered as possible on the location of light source **301** on remote control **103**, and has aspect ration A. The values X_0 and Y_0 indicate the starting location of the selected photograph, and the values W_1 and H_1 indicate the width and height respectively of the selected photograph. Note that the selected photograph may be constrained to a fixed size by setting W_{max} and W_{min} equal to each other. Setting $W_{min} = 0$ and $W_{max} = W_R$ configures the algorithm to find the largest selected photograph that can be centered on the remote control light source **301** within reference photograph **602**.

Once the size and location of the selected photograph have been determined, camera **100** can take a final photograph. A final photograph is the photograph that camera **100** has prepared to take. The preparations may involve preliminary photographs used for focusing, exposure determination, framing, or other purposes, as well as selecting a region to photograph. Photographing the selected region may involve taking a digital image of the entire field of view of the camera, and then extracting a subarray corresponding to the selected region from the digital image for storage. This is especially true if the electronic array light sensor in digital camera **100** is a charged coupled device (CCD) sensor or a complementary metal oxide

semiconductor (CMOS) sensor. All pixels on the CCD or CMOS sensor, not just those in the selected region, may accumulate charge during the taking of the photograph, even though only those in the selected region will contribute to the final photograph. Digital camera **100** may measure the charges from all of the pixels on the electronic array light sensor and extract the final photograph from the resulting digital image, or may discard some or all of the unnecessary charges without measuring them. Whether accomplished by any of these methods, the effective result is that the selected region is photographed.

In one example embodiment, light source **301** may be interrupted so that it emits no light during the taking of a still photograph, and thus does not appear obtrusively in the final photograph.

Optionally, camera **100** may use the location of remote control light source **301** as the center of a focus region, thus preferentially focusing on subjects in the vicinity of the remote control. Typically, a digital camera performs focusing by maximizing the image spatial contrast in a selected region of the camera's field of view. The focus region may be arbitrarily selected, but is often in the center of the camera's field of view. Selecting a focus region centered on remote control light source **301** ensures that the portion of the scene that is of greatest interest, as indicated by the presence of the remote control, will be in focus. U.S. Patent 6,466,742, having a common assignee with the present application, describes a "focus attracting" remote control, and is hereby incorporated for all that it discloses.

In another example embodiment, camera **100** is capable of making video recordings. A video recording may be any sequence of successive digital images, sometimes called "video frames", captured at substantially regular intervals. The digital images need not be of a size similar to television video nor need they be taken

at a frequency similar to television video. In a preferred configuration, light source **301** on remote control **103** flashes at a frequency of about one half the frequency of digital image capture during video recording. This arrangement ensures that most video frames will show a difference in the state of light source **301** as compared with the immediately preceding video frame. For example, if light source **301** flashes at between 0.4 and 0.6 times the frequency of digital image capture, then at least 80 percent of successive video frames will show a change in the state of light source **301** from the previous frame. Camera **100** may adjust the composition of the video recording by re-selecting a region to photograph during recording as light source **301** may move. In this way, camera **100** can simulate pan and tilt motions of a gimbal-mounted camera, but without the complexity of moving the camera.

Unless precise synchronization is provided between the flashing of light source **301** and the capture of video frames, light source **301** may appear in some video frames. In order to reduce the obtrusiveness of having light source **301** in the video sequence, automatic image processing using information from adjacent frames or adjacent pixels may be used remove the effect of the light source.

Figure 11 illustrates one simple example technique for removing light source **301** from a video frame. Digital images **1101** and **1102** are consecutive frames from a video recording. As described previously, the presence of light source **301** has been detected in two pixels by computing an element-by-element difference frame **1103** between the consecutive frames **1101** and **1102**. Once light source **301** has been located, its effect can be removed by copying pixel values from the most recent frame taken when light source **301** was off.

Other techniques may be envisioned for removing the effect of light source **301** from video frames. For example, pixel information from both preceding and

following frames could be combined to replace pixel data in a particular frame, for example by interpolation. Alternatively, the effect of light source **301** could be removed from a frame without reference to other frames, by replacing pixel data with information based on surrounding pixels. If the light emitted by light source **301** is substantially monochromatic and camera **100** uses selective wavelength filtering on some pixels to generate color photographs, then light source **301** may be detected by analyzing only those pixels that can sense the light wavelengths emitted by light source **301**. For example, if light source **301** is a red light emitting diode (LED), then it is likely that only the red-sensing pixels in the camera need be examined to detect the light source **301**, or need be adjusted to remove the effect of light source **301** from a frame.

In another example embodiment, which may be combined with other example embodiments already described, camera **100** includes an optical zoom function, and uses its optical zoom capability to optimize photographic quality in some situations. In some cases, a selected photograph is defined that is completely contained within reference photograph **602** with excess area surrounding the selected photograph. That is, the selected photograph is not at the edge of reference photograph **602**. Selected photograph **601** in the Figures is of this kind, while selected photographs **901A** and **1001** are not.

In this situation, camera **100** can improve the resolution at which it can photograph the selected region by activating its optical zoom function so that the camera's field of view just encompasses the selected region. That is, the focal length of the lens is increased, causing the camera's field of view to be narrowed, until the selected photographic region is at the edge of the camera's field of view.

Figure 12 illustrates using optical zoom to improve the resolution of a selected photograph. Selected photograph **1202** is entirely contained in reference photograph **602**, with excess area surrounding it. Camera **100** may actuate its optical zoom such that reference photograph **1201**, rather than reference photograph **602**, covers the entire electronic array light sensor in camera **100**. Selected photograph **1202** can then be extracted from reference photograph **1201**, but at higher resolution than if it had been extracted from reference photograph **602**.

In yet another example embodiment, light source **301** may be used both for digital framing of photographs, and for controlling other functions of digital camera **100**. For example, light source **301** may flash in a uniquely identifiable way (such as remaining on for three consecutive preliminary photographs or video frames, and then shutting off) to signal to the camera to take a final photograph. Signaling the camera to take a final photograph may also be called actuating the camera's shutter release. Using the same light source for digital framing and for controlling other camera functions saves the expense of having two different signaling methods.

The foregoing description of the present invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed, and other modifications and variations may be possible in light of the above teachings. The embodiment was chosen and described in order to best explain the principles of the invention and its practical application to thereby enable others skilled in the art to best utilize the invention in various embodiments and various modifications as are suited to the particular use contemplated. It is intended that the appended claims be construed to include other alternative embodiments of the invention except insofar as limited by the prior art.